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National Engineering Handbook

Part 642 Specifications for Construction Contracts

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Part 642 Specifications for Construction Contracts

Contents:

Chapter 2 National Standard Construction Specifications

	Effective date	
	Instruction	Specification
Site preparation		
1—Clearing	5/01	5/01
2—Clearing and Grubbing	5/01	5/01
3—Structure Removal	5/01	5/01
4—Channel Clearing and Shaping	5/01	5/01
5—Pollution Control	5/01	5/01
6—Seeding, Sprigging, and Mulching	5/01	5/01
7—Construction Surveys	5/01	5/01
8—Mobilization and Demobilization	5/01	5/01
9—Traffic Control	5/01	5/01
10—Water for Construction	5/01	5/01
Foundation work		
11—Removal of Water	5/01	5/01
12—Relief Wells	5/01	5/01
13—Piling	5/01	5/01
14—Pressure Grouting	5/01	5/01
Earthwork		
21—Excavation	5/01	5/01
22—(Reserved)		
23—Earthfill	5/01	5/01
24—Drainfill	5/01	5/01
25—Rockfill	5/01	5/01
26—Topsoiling	5/01	5/01
27—Diversions and Waterways	5/01	5/01
28—Lime Treated Earthfill	5/01	5/01
29—Soil-Cement	5/01	5/01
Concrete and reinforcement		
31—Concrete for Major Structures	5/01	11/05
32—Structure Concrete	5/01	5/01
33—Shotcrete	5/01	5/01
34—Steel Reinforcement	5/01	11/05
35—Concrete Repair	5/01	5/01
36—Roller Compacted Concrete	11/05	11/05

	Effective date	
	Instruction	Specification
Nonmetal pipe conduits and drains		
41—Reinforced Concrete Pressure Pipe Conduits	5/01	5/01
42—Concrete Pipe Conduits and Drains	5/01	5/01
43—Clay Pipe	5/01	5/01
44—Corrugated Polyethylene Tubing	5/01	5/01
45—Plastic Pipe	5/01	5/01
46—Tile Drains	5/01	11/05
Metal pipe conduits		
51—Corrugated Metal Pipe	5/01	5/01
52—Steel Pipe	5/01	5/01
53—Ductile-Iron Pipe	5/01	5/01
Riprap and slope protection		
61—Rock Riprap	5/01	11/05
62—Grouted Rock Riprap	5/01	5/01
63—Treatment of Rock Surfaces	5/01	5/01
64—Wire Mesh Gabions and Mattresses Twisted (Woven) or Welded Mesh	5/01	11/05
Water control gates and valves		
71—Water Control Gates	5/01	5/01
Miscellaneous structural work		
81—Metal Fabrication and Installation	5/01	5/01
82—Painting Metalwork	5/01	11/05
83—Timber Fabrication and Installation	5/01	5/01
84—Painting Wood	11/05	11/05
Miscellaneous construction		
91—Chain Link Fence	5/01	5/01
92—Field Fence	5/01	5/01
93—Identification Markers or Plaques	5/01	5/01
94—Contractor Quality Control	5/01	5/01
95—Geotextile	5/01	5/01
96—Field Office	5/01	5/01
97—Flexible Membrane Liner	11/05	11/05
98—Geosynthetic Clay Liner	11/05	11/05

Chapter 3 National Standard Material Specifications

Instructions for use
Construction Specification 97—Flexible Membrane Liner

1. Applicability
Construction Specification 97 is applicable to the placement of flexible membrane liners in liquid containment systems to control seepage.

2. Material specifications
Material Specification 594, Flexible Membrane Liner, is complementary to this specification.

3. Included items
Items to be included in the contract drawings and specifications follow:

a. The type of liner material being used and the required thickness.

b. The required lines and grades of the liner subgrade and the cover layer, if applicable.

c. Details of panel placement, orientation, and anchorage.

d. Requirements for subgrade compaction.

e. Requirements of any cushioning material to be used and the material references for the same.

f. Requirements for a geosynthetic rub sheet, as mentioned in section 6, Liner Placement

g. Requirements for under drains and the associated materials.

h. Details for any loading, unloading, or cleanout ramps; including batten strips or other means of fastening.

i. Details for pipe outlets and boots or appurtenances to fit the liner to the pipe, concrete, or steel structures, as mentioned in section 11, Appurtenances.

j. Details of gas vents and their locations, as mentioned in section 12, Gas Vents and Drainage.

k. Details for fences, ladders, or other safety features.

l. Requirements for cover soil, as mentioned in section 13, Cover Soil.

m. Requirements for concrete placement including the slump of the concrete, as mentioned in section 14, Placement of concrete.

n. Any special instructions related to the materials, installation, and onsite quality control testing.

4. Items of work and construction details
Starting at the top of page 97–6, prepare and outline job specific "Items of Work and Construction Details" (IWCD) in accordance with these instructions.

Construction Specification 97—Flexible Membrane Liner

1. Scope
The work consists of furnishing and installing a flexible membrane liner, including appurtenances, cover soil, and concrete pads.

2. Material
The liner, welding rod, vent covers, pipe boots, gaskets, metal battens, clamps, bolts, embed channel, adhesive, and sealant shall conform to the requirements of Material Specification 594, the applicable provisions in this specification, and details as shown on the drawings.

3. Shipping and storage
Liner material shall be delivered, handled, and stored according to the manufacturer's recommendations. Liner material shall be stored and protected from puncture, dirt, grease, excessive heat, exposure to ultraviolet radiation, or other damage.

Damaged liner material shall be repaired or replaced. Liner material that cannot be satisfactorily repaired to comply with the requirements of Material Specification 594 shall be removed from the job site.

4. Subgrade preparation
Subgrade soils shall be compacted to provide a smooth, firm, and unyielding foundation. All subgrade surfaces shall be free of organic material, rocks larger than 3/8 inch, angular rocks, or other sharp objects. Surface deformations shall not exceed 1 inch. Standing water, mud, and snow shall be removed prior to liner placement.

The liner shall not be placed until the subgrade has been approved by the engineer.

5. Anchor trench
The anchor trench provides permanent anchoring for the liner and shall be constructed in accordance with the drawings. The trench corners shall be slightly rounded to prevent sharp bends in the liner.

If sloughing of the trench occurs, the sloughed soils shall be removed and necessary repairs shall be made to provide a smooth trench wall. Standing water, mud, and snow shall be removed prior to liner placement and trench backfill.

Soil material used for backfilling the trench shall meet the requirements specified in section 4 of this specification. The trench shall be backfilled in two equal lifts and compacted by rolling with rubber-tired equipment or manually directed compaction equipment.

6. Liner placement
The liner shall be installed with a minimum of handling by using a spreader bar assembly attached to a front-end loader, track-hoe bucket, or by other methods recommended by the liner manufacturer. The liner shall be placed parallel to the direction of maximum slope. During installation, the liner shall be secured with sandbags to protect it from wind uplift forces. The liner shall be seamed and secured by the end of each workday.

Construction equipment shall not be allowed to operate directly on the liner except for all terrain vehicles that produce ground pressure less than 5 pounds per square inch.

The liner shall not be placed during foggy conditions, precipitation events, or in the presence of excessive winds. High-Density Polyethylene (HDPE) and Linear Low-Density Polyethylene (LLDPE) liners shall not be placed when the temperature is less than 50 degrees Fahrenheit. Polypropylene (PP) liners shall not be placed when the temperature is less than 40 degrees Fahrenheit. Polyvinyl Chloride (PVC) liners shall not be placed when the temperature is less than 40 degrees Fahrenheit or greater than 105 degrees Fahrenheit. Ethylene Propylene Diene Monomer (EPDM) liners shall not be placed when the temperature is less than zero degrees Fahrenheit or greater than 120 degrees Fahrenheit.

The liner shall be loosely laid over the subgrade with sufficient slack to accommodate thermal expansion and contraction. Each panel shall be laid out and positioned to minimize the number and length of liner seams and in accordance with the manufacturer's recommendations. The methods used to place panels shall minimize wrinkles especially along field seams. Wrinkles shall not exceed 6 inches in height or "fold over" during soil cover placement or other load application. When specified in section 16 of this specification or recommended by the manufacturer, a geosynthetic rub sheet shall be used under the liner when dragging or moving the panels.

Seam overlap—Liner panels shall have a minimum seam overlap of 4 inches for hot wedge welding, hot air welding, chemical fusion welding, adhesive seams, inseam tape, and cover strip seams. A minimum seam overlap of 3 inches shall be used for extrusion-welded seams. Upslope panels shall overlap downslope panels to produce a shingle effect for drainage.

7. Seaming methods

HDPE, LLDPE, PP—The primary method of seaming shall be hot wedge fusion welding. Fillet extrusion welding shall be used for repairs, T-seams, and detail work. Hot air fusion or chemical fusion welding may be used for PP. Seaming shall not be performed when the ambient sheet temperature is below 45 degrees Fahrenheit or above 90 degrees Fahrenheit.

PVC—Seams shall be joined using hot wedge fusion welding, hot air fusion welding, chemical fusion welding, or an adhesive. Special precautions, as recommended by the manufacturer, shall be taken for seam joining if the ambient sheet temperature is above 105 degrees Fahrenheit. Seam joining shall not be performed when the ambient sheet temperature is below 40 degrees Fahrenheit or above 140 degrees Fahrenheit.

EPDM—Seams shall be joined using double-faced inseam tape or a cover strip recommended by the manufacturer. Seaming shall not be performed when the ambient sheet temperature is below zero degrees Fahrenheit or above 120 degrees Fahrenheit.

8. Seaming procedures

Seaming shall extend to the outside edge of the liner to be placed in the anchor trenches. Seaming shall not be conducted in the presence of moisture, dust, dirt, standing water, or soft subgrade. Seaming procedures shall be in accordance with the liner manufacturer's recommendations.

Hot wedge welding—Hot wedge welding shall be accomplished by a double-wedge fusion welder that produces a double track weld. Welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The welder shall be calibrated at least once per day at the beginning of each seaming period.

Fillet extrusion welding—Extrusion welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The extrusion welder shall be calibrated at least once per day at the beginning of each seaming period. To ensure proper bonding of the extrusion weld, edges of the patch material and the adjacent liner shall be properly abraded by a light grinding. This operation shall be done no more than 15 minutes before the welding operation. The abrasion process shall remove no more than 10 percent of the material thickness.

Hot air welding—Hot air welding shall be accomplished by a single- or double-tracked fusion welder. Welding equipment and accessories shall be in accordance with the liner manufacturer's recommendations. The welder shall be calibrated at least once per day at the beginning of each seaming period.

Chemical fusion welding—The chemical fusion agent shall be applied to both panels by a squeeze bottle or paintbrush. The width of application shall be a minimum of 2 inches. Pressure shall be applied to the seam in accordance with the liner manufacturer's recommendations to provide adequate contact between the panels. Excess agent extruded from the seam shall be immediately removed.

Adhesive—Adhesive shall be approved by the manufacturer and consist of material with a life expectancy similar to that of the liner material. The adhesive shall be applied to both panels by a paintbrush or other approved method. The adhesive shall cover the entire seam overlap. Pressure shall be applied to the seam in accordance with the liner manufacturer's recommendations to provide adequate contact between the panels. Excess adhesive extruded from the seam shall be immediately removed.

Inseam tape—A primer shall be applied to both panels by a scrub pad or other approved method recommended by the manufacturer. The primer shall cover the entire seam overlap. As soon as the primer has flashed, install the tape on the bottom sheet, remove tape backing, lap the top sheet over the tape, and roll with sufficient pressure to provide adequate contact between the panels.

Cover strip—A primer shall be applied to both panels by a scrub pad or other approved method recommended by the manufacturer. The top sheet shall be lapped over the bottom sheet and rolled to provide contact between the panels. Additional primer shall be applied to cover the entire seam overlap. As soon as the primer has flashed, install the cover strip and roll it with sufficient pressure to provide adequate contact between the cover strip and the panels.

9. Seam testing

Field seams shall be nondestructively tested over their full length. Seam testing shall be performed as the work progresses.

Nondestructive seam testing—Air pressure tests shall be performed in accordance with ASTM D 5820 on all double-track fusion seams. The air pressure test equipment and procedures shall conform to this specification and the liner manufacturer's recommendations. Pressurize the air channel to 25 to 30 pounds per square inch for HDPE, LLDPE, and PP liners, 15 to 25 pounds per square inch for 30 mil PVC liners, and 20 to 30 pounds per square inch for 40 mil PVC liners.

Monitor any pressure drops for 5 minutes. A loss of pressure in excess of 4 pounds per square inch for HDPE, LLDPE, and PP liners, 5 pounds per square inch for 30 mil PVC liners, 4 pounds per square inch for 40 mil PVC liners, or a continuous loss of pressure is an indication of a leak. The location of all defective seams shall be marked and repaired.

Vacuum box tests shall be performed in accordance with ASTM D 5641 on all seams and repairs made by extrusion welds and may be used on PP chemical fusion welds. Vacuum box tests shall not be used on PVC liner seams. The location of all defective seams shall be marked and repaired.

Air lance tests shall be performed in accordance with ASTM D 4437 on single-track fusion welds, chemical fusion welds, and on adhesive PVC seams and EPDM seams, and may be used on PP chemical fusion seams. The location of all defective seams shall be marked and repaired.

Destructive seam testing—If specified in section 16 of this specification, seam samples shall be cut at no more than one sample per 500 feet of weld for destructive seam testing. All destructive seam samples shall be tested in shear and peel modes in accordance with ASTM D 6392 to verify seams meet the requirements of Material Specification 594.

10. Repairs

All defective liner areas and failed seams shall be repaired and retested.

Tears, punctures, material defects—All tears, punctures, and material defects in the liner shall be repaired by installing a patch over the defective area. Surfaces of the liner to be patched shall be cleaned before the repair. All patches shall be of the same liner material and extend a minimum of 6 inches beyond the edges of the defect area. All patches shall have rounded corners and shall be seamed to the liner. Holes that are less than 0.25 inch in diameter on HDPE, LLDPE, and PP liners shall be repaired by a bead of extrudent.

Seam repair—Failed seams shall be repaired by installing a cap strip over the entire length of failed seam. The cap strip shall be of the same liner material and shall extend beyond the failed seam a minimum of 6 inches in all directions. Alternatively, the upper flap may be extrusion welded to the liner along the entire length of the failed seam.

11. Appurtenances

The liner shall be mechanically attached to pipe, concrete, or steel structures as shown in the drawings and according to liner the manufacturer's recommendations.

Pipe boots—Factory fabricated pipe boots shall be used as specified in section 16 of this specification. Pipe boots fabricated in the field shall be from the same material as the liner. The boots shall be welded and clamped to pipes of the same material as the liner. They shall be clamped to other types of pipe as shown in the drawings, or as recommended by the manufacturer, to provide a leak-free attachment.

Metal battens—Metal battens shall meet the requirements of Material Specification 594 and shall be installed according to the drawings and the liner manufacturer's recommendations. The battens shall be bolted to concrete by bolts on 6-inch intervals to create a leak-free connection under submerged conditions. Bolt spacing may be increased to 12 inches for connections above the fluid level.

Embed channel—Embed channel shall meet the requirements of Material Specification 594 and be installed according to drawings and the liner manufacturer's recommendations. The embed channel shall be prefabricated to the dimensions shown on the drawings. All sections of the channel shall be continuously welded to subsequent sections before installation in the concrete forms. All corners shall be miter cut and welded on all sides.

12. Gas vents and drainage

Gas vent flaps vent pipes, and drainage systems shall be installed as specified in section 16 of this specification and as shown on the drawings.

13. Cover soil

If specified in section 16 of this specification, cover soil and placement method shall be in accordance to the drawings and shall conform to this specification and the liner manufacturer's recommendations. Cover soils shall meet the same requirements as specified for subgrade soils in section 4 of this specification. Cover soil placement shall be performed by a loader or bulldozer with ground pressure of less than 8 pounds per square inch. Cover soil shall not be dropped onto the liner from a height of more than 3 feet. Following construction of an access ramp, the soil shall be placed from the bottom of the slope upward. Construction equipment or machinery shall not operate directly on the liner. Cover soil shall be placed during the coolest part of the day.

14. Placement of concrete

Concrete placement for ramps and other appurtenances shall be in accordance with the drawings and as specified in section 16 of this specification. All reinforcing steel shall be placed on flat-footed plastic rebar chairs. All rebar splices shall be fully tied. On slopes, concrete shall be placed from the bottom of the slope to the top and have a slump as specified in section 16 of this specification. Internal vibrators shall be used to consolidate concrete. Metal shovels and rodding shall not be used to consolidate or place the concrete. Concrete forms shall be held in place by methods that avoid damaging the liner.

15. Measurement and payment

For work for which specific unit prices are established in this contract, the quantity of liner installed shall be determined to the nearest square foot by measurement of the covered surfaces only, disregarding that for anchorage, seams, and overlaps. Payment for items listed separately in the contract bid schedule shall be made at the contract price for those items. Such payment shall constitute full compensation for furnishing, shipping, and installing the liner including all pipe boots or shirts, mechanical attachments to pipes and structures, and other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract, but not listed in the bid schedule, is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 16 of this specification.

16. Items of work and construction details

Material Specification 594—Flexible Membrane Liner

1. Scope

This specification covers the quality of High Density Polyethylene (HDPE), Linear Low Density Polyethylene (LLDPE), Ethylene Propylene Diene Monomer (EPDM), Poly Vinyl Chloride (PVC), and Polypropylene (PP) flexible liner, seams, gaskets, metal battens, bolts, embed channels, clamps, and sealant.

2. Material

Liner—The liner shall have a nominal thickness as specified. The liner shall be manufactured to be suitable for use in the specified exposed or buried conditions. It shall conform to the requirements of this specification, Construction Specification 97, and the requirements shown on the drawings.

Gaskets, metal battens, clamps, bolts, embed channels, welding rod, adhesive, and sealant—Gasket material shall be neoprene, closed-cell medium, 0.25 inch thick, with adhesive on one side, or other gasket material as approved by the liner manufacturer. Metal battens shall be 0.25-inch-thick by 2-inch-wide stainless steel. Clamps shall be 0.5-inch-wide stainless steel. Bolts shall be stainless steel. The embed channel and welding rod shall have the same properties as the liner. Adhesive shall be approved by the manufacturer and shall consist of material with a life expectancy similar to the liner material. Sealant shall be as recommended by the manufacturer. Silicone sealant shall not be used with PVC liner materials.

Vents and pipe boots—Vents and pipe boots shall be made of the same material as the liner.

3. Liner properties

The liner shall be uniform in color, thickness, and surface texture. The liner shall be resistant to fungal or bacterial attack and free of cuts, abrasions, holes, blisters, contaminants, and other imperfections.

HDPE and LLDPE—The HDPE or LLDPE liner shall be manufactured from virgin polymer material and shall meet the property values specified in tables 594–1 through 594–4 as applicable.

EPDM—The EPDM liner shall be formulated from virgin compounding materials and shall meet the property values specified in tables 594–5 and 594–6 as applicable. Regrind, reworked, or trim materials shall be from the same manufacturer and the same formulation as the liner. Recycled materials shall not be allowed.

PVC—The PVC liner shall be manufactured from virgin polymers and other compounding materials and shall meet the property values specified in table 594–7 as applicable. Regrind, reworked, or trim materials shall be from the same manufacturer and the same formulation as the liner. No more than 10 percent regrind, reworked, or trim materials shall be used to manufacture the liner. Recycled materials shall not be allowed.

The PVC compound shall consist of 50- to 70-percent PVC resin, by weight. Liquid plasticizers shall be mixed until completely absorbed by the resin powder. Other additives shall be thoroughly mixed into the resin.

PP—The PP liner shall be manufactured from virgin polymer material and shall meet the property values specified in tables 594–8 and 594–9 as applicable.

A reinforced PP liner shall consist of one ply of reinforcing polyester (scrim) between two sheets of PP. The polyester scrim shall be of an open weave that permits strike-through of the PP.

Table 594–1 Requirements for smooth HPDE liner

Property	Test methods	Requirements* nominal thickness 30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Tensile properties	ASTM D 638			
yield stress, lb/in	(type IV at 2 in/min)	63	84	126
break stress, lb/in		114	152	228
yield elongation, %		12	12	12
break elongation, %		700	700	700
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	54	72	108
Carbon black content, %	ASTM D 1603	2-3	2-3	2–3
Carbon black dispersion	ASTM D 5596	Cat 1–2	Cat 1–2	Cat 1–2
Seam properties	ASTM D 6392			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported for the test method.
** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 594–2 Requirements for textured HDPE liner

Property	Test methods	Requirements* nominal thickness 30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Tensile properties	ASTM D 638			
yield stress, lb/in	(type IV at 2 in/min)	63	84	126
break stress, lb/in		45	60	90
yield elongation, %		12	12	12
break elongation, %		100	100	100
Tear resistance, lb	ASTM D 1004	21	28	42
Puncture resistance, lb	ASTM D 4833	45	60	90
Carbon black content, %	ASTM D 1603	2 - 3	2 - 3	2 – 3
Carbon black dispersion	ASTM D 5596	Cat 1–2	Cat 1–2	Cat 1–2
Seam properties	ASTM D 6392			
shear strength, lb/in		60	80	120
peel strength, lb/in**		39/FTB	52/FTB	78/FTB

* All values, unless specified otherwise, are minimum average roll values as reported by the specified test method.
** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 594–3 Requirements for smooth LLDPE liner

Property	Test methods	Requirements* nominal thickness 30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.915	0.915	0.915
Tensile properties	ASTM D 638			
break stress, lb/in	(type IV at 2 in/min)	114	150	228
break elongation, %		800	800	800
Tear resistance, lb	ASTM D 1004	16	22	33
Puncture resistance, lb	ASTM D 4833	42	56	84
Carbon black content, %	ASTM D 1603	2–3	2–3	2–3
Carbon black dispersion, %	ASTM D 5596	Cat 1–2	Cat 1–2	Cat 1–2
Seam properties	ASTM D 6392			
shear strength, lb/in		44	58	90
peel strength, lb/in**		37/FTB	50/FTB	75/FTB

* All values, unless otherwise specified, are minimum average roll values as reported for each test method.
** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 594–4 Requirements for textured LLDPE liner

Property	Test methods	Requirements* nominal thickness 30 mil	40 mil	60 mil
Density, g/cc	ASTM D 1505	0.915	0.915	0.915
Tensile properties	ASTM D 638			
break stress, lb/in	(type IV at 2 in/min)	60	80	120
break elongation, %		350	350	350
Tear resistance, lb	ASTM D 1004	17	22	33
Puncture resistance, lb	ASTM D 4833	33	44	66
Carbon black content, %	ASTM D 1603	2–3	2–3	2–3
Carbon black dispersion, %	ASTM D 5596	Cat 1–2	Cat 1–2	Cat 1–2
Seam properties	ASTM D 4437			
shear strength, lb/in	(1 in wide at 2 in/min)	40	53	79
peel strength, lb/in**		33/FTB	44/FTB	66/FTB

* All values, unless otherwise specified, are minimum average roll values as reported for each test method.
** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 594–5 Requirements for nonreinforced EPDM liner

Property	Test methods	Requirements* - - nominal thickness - - 45 mil	60 mil
Specific gravity	ASTM D 792	1.1	1.1
Tensile properties	ASTM D 882		
break stress, lb/in	(Type IV at 20 in/min)	50	50
break elongation, %		400	400
Tear resistance, lb	ASTM D 1004	9	11
Puncture resistance, lb	ASTM D 4833	35	60
Low temperature brittleness, °F	ASTM D 1790	<-45	<-45
Seam properties	ASTM D413/D4437		
shear strength, lb/in**	(NSF modified 20 in/min strain rate)	35	35
peel strength, lb/in***		14	14

* All values, unless specified otherwise, are minimum average **roll values** as reported for the test method.
** At 200 percent strain.
*** Cohesive bond mode.

Table 594–6 Requirements for reinforced EPDM liner

Property	Test methods	Requirements* nominal thickness 45 mil
Specific gravity	ASTM D 792	1.1
Tensile properties	ASTM D 751 Method A	125
Tear resistance, lb	ASTM D 5884 Method B	130
Puncture resistance, lb	FTMS 101C Method 2031	45
Ply adhesion, lb/in	ASTM D 413 Machine method	7
Low temperature brittleness, °F	ASTM D 1790	< –45
Seam properties		
shear strength, lb/in**	ASTM D 751	35
peel strength, lb/in***	ASTM D 413	14

* All values, unless specified otherwise, are minimum average **roll values** as reported for the test method.
** At 200 percent strain.
*** Cohesive bond mode.

Table 594–7 Requirements for PVC liner

Property	Test methods	Requirements* - - nominal thickness - - 30 mil	40 mil
Specific gravity	ASTM D 792	1.2	1.2
Tensile properties	ASTM D 882		
break strength, lb/in	(MD and XD)	73	97
elongation at break, %		350	400
Tear resistance, lb	ASTM D 1004	8.5	10.5
Low temperature brittleness, °C	ASTM D 1790	< –29	< –29
Dimensional stability, % (maximum)	ASTM D 1204	3	3
Hydrostatic resistance, lb/in^2	ASTM D 751 Method A	100	120
Seam properties	ASTM D 6392/D 6214/D 4437 **		
shear strength, lb/in		58	77
peel strength, lb/in		15	15

* All values, unless specified otherwise, are minimum average **roll values** as reported for the test method.
MD Machine direction
XD Cross-machine direction
** ASTM D 6392 shall be used for thermally welded seams, D 6214 for chemically welded seams, and D 4437 for all other types.

Table 594–8 Requirements for unreinforced PP liner

Property	Test methods	Requirements* nominal thickness 30 mil	40 mil	60 mil
Specific gravity	ASTM D 792	0.90	0.90	0.90
Tensile Properties	ASTM D 638			
break stress, lb/in	(Type IV at 20 in/min)	60	72	130
break elongation, %		600	600	600
Tear resistance, lb	ASTM D 1004	9	11	16
Puncture resistance, lb	ASTM D 4833	28	35	65
Carbon black content, %	ASTM D 1603	2–4	2–4	2–4
Carbon black dispersion	ASTM D 5596	Cat 1–2	Cat 1–2	Cat 1–2
Low temperature brittleness, °C	ASTM D 1790	<–40	<–40	<–40
Seam properties	ASTM D 6392/D6214/D 4437 ***			
shear strength, lb/in		35	45	55
peel strength, lb/in***		20/FTB	30/FTB	40/FTB

* All values, unless specified otherwise, are minimum average **roll values** as reported for the test method.
** ASTM D 6392 shall be used for thermally welded seams, D 6214 for chemically welded seams, and D 4437 for all other types.
*** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.

Table 594-9 Requirements for reinforced PP liner

Property	Test methods	Requirements* - - - nominal thickness - - - 36 mil	45 mil
Specific gravity	ASTM D 792	0.90	0.90
Tensile properties	ASTM D 751 Method A	225	225
Tear resistance, lb	ASTM D 5884 Method B	55	75
Puncture resistance, lb	FTMS 101C Method 2031	200	250
Ply adhesion, lb/in	ASTM D 413 Machine Method	20	20
Carbon black content, %	ASTM D 1603	2–4	2–4
Carbon black dispersion	ASTM D 5596	Cat 1–2	Cat 1–2
Low temperature brittleness, °C	ASTM D 2136	< –40	< –40
Seam properties			
shear strength, lb/in	ASTM D 751	160	200
peel strength, lb/in**	ASTM D 413	20/FTB	20/FTB

* All values, unless specified otherwise, are minimum average **roll values** as reported for the test method.
** Film tear bond: A failure of one of the bonded sheets by tearing prior to complete separation in the bonded area.